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**THE SUGAR BEET IN GERMANY, WITH SPECIAL
ATTENTION TO ITS RELATION TO CLIMATE¹**

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If the object of this paper were merely a recapitulation of what has been written upon the subject of the sugar beet or beet sugar, it would hardly be worth while. The literature is very extensive in quantity, but shows no very great variety. Much of it is repetition, in slightly modified form, of facts set forth in earlier works. In essentially no instance is the subject treated from a general geographic point of view. The purpose of this paper lies in an attempt to present the subject from such a viewpoint, with emphasis, however, in two directions, namely, (a) graphical representation of the statistics accompanied by an interpretation and (b) an inquiry into the relation between the sugar beet crop and climate. In order to establish somewhat of a background, some preliminary remarks not purely geographic must be introduced.

Brief History. The sugar beet is a cultivated product developed from the *Runkelrübe* (beet root), native, it seems, to the more moist parts of western and southern Asia. Although known probably as early as 500 B. C., it was not cultivated in Europe until the eighteenth century. Whether the common beet went first to China and then westward to Europe or followed some other course is still unsettled. It is fairly certain, however, that it finally reached Europe via the Mediterranean countries, beginning its general westward movement from Egypt, first following the coast to the east and

¹Prepared in the Department of Geography of the University of Leipzig, March, 1914. The writer expresses his appreciation to Professor Joseph Partsch for his ever-ready cooperation.

north and thence the north coast of the sea westward (1-5)². It is interesting to note that to-day the sugar beet occurs relatively seldom in the fields of these Mediterranean lands.

Until the sugar beet arrived in Europe its value as a plant with a high sugar content was not appreciated. Only as the result of research by Andreas Marggraf in Berlin, then "Director of the Physical Section in the Academy of Sciences," was the fact revealed (1747) that the beet root contains a high percentage of common sugar. In 1801 the first *Fabrik*³ was erected in Cunern, near Breslau in Silesia, by Franz Achard, a former student under Marggraf (3). This beginning was encouraged by the conquering Napoleon (3), who was sweeping all Europe before him. Realizing the value of home-produced sugar, he set up a prize of 100,000 francs for the economically successful production of sugar from a native plant. In addition, in 1812, he built four *Fabriken*, declared against further import of sugar and established a school in France where people might learn how to cultivate the plant and subsequently extract the sugar. However, when he died the industry in Germany became dormant, not again to become active until about 1840. Since this date the industry has fluctuated in activity, affected always by military as well as economic wars.

Distribution. The sugar beet, evolved since the days of Marggraf, has spread from Germany, where it has had its maximum development, to not only all European countries but across the seas to the Americas. The map (Fig. 1) indicates its occurrence only where grown in quantities commercially important. Its very limited area in contrast with the widespread distribution of sugar cane should be noted. Also the fact is worth noting that, despite the very ready adaptability of the plant, it is confined essentially to the intermediate zone, usually the cooler parts.

Uses. The very extensive use of beet sugar is not generally appreciated. Practically all the table sugar in Continental Europe is derived from the beet. Molasses and a coarse brown sugar, by-products of the refined white sugar, are of less consequence. The refined sugar reaches the market as "granulated," as "loaf-sugar"—cones weighing from 3 to 30 kilograms (6½ to 66 lbs.)—as "domino" or "lump-sugar," and as "pulverized" sugar. The demand for sugar

² The numbers in parentheses refer to the numbered references in the bibliography at the end of the paper.

³ The German form and its plural, *Fabriken*, will be employed throughout to denote the building wherein the sugar is extracted from the beet. The English translation "factory" is hardly applicable.

does not stop at the dinner-table. Every manufacturer of chocolate, candies, jams, jellies, marmalades, fruit preserves, pastry, liquors and many other products uses tremendous quantities of sugar⁴. Such people are necessarily affected by every decided fluctuation in the sugar crop. Hence the cultivation of a plant with a very large sugar content and the improvement of processes for extracting and refining the sugar become vital problems.

The Plant. The scientific name of the cultivated sugar beet is *Beta altissima* (6), a variety derived from the common beet (*Futter-rübe*), *Beta vulgaris*. A number of varieties have been developed,

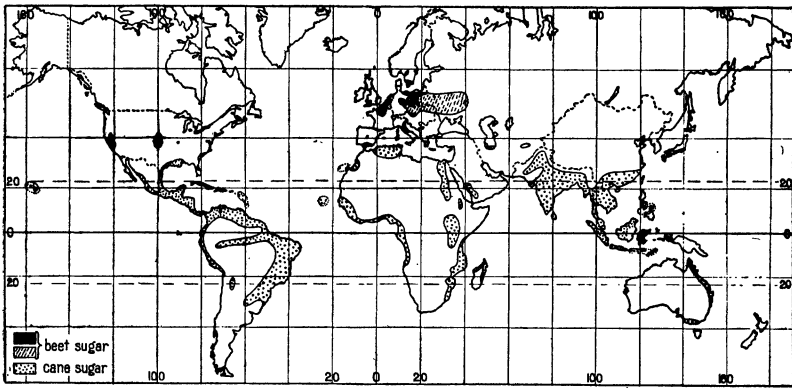


FIG. 1.—World distribution of beet sugar and cane sugar areas.

Outline adapted from Haack-von Seydlitz atlas, Gotha, 1913. Small scale of map necessitated considerable generalization.

Refs.—A. Scobel: *Handels-Atlas zur Verkehrs- und Wirtschaftsgeographie*, 1900-1902. E. Friedrich: *Geographie des Welthandels*, 1911. Haack-von Seydlitz: *Oberstufen-Atlas für höhere Lehranstalten*, 1913.

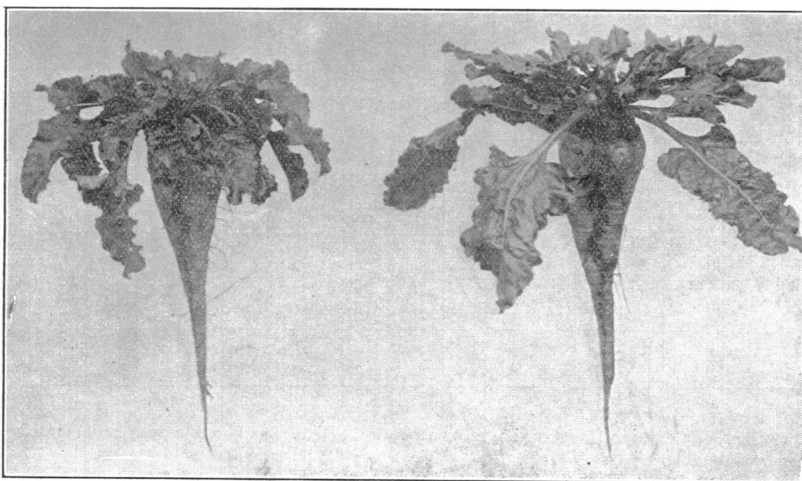
the most conspicuous of which can be classified into four groups (1):—(a) The Silesian white beet; (b) the Imperial beet in the Province of Saxony; (c) the small Wanzleben beet, quite generally distributed; and (d) the Vilmorin beet of French origin. In addition to these principal kinds a number of local types, valued very highly, have been developed. One of the better known is illustrated by Figure 2. The Delitzsch "Elite" has been cultivated in the region about Delitzsch, a small town ten miles north of Leipzig.

The shape of the beet is of prime consideration, since most of the sugar is contained within a distance equal to the width of two fingers measured from the top of the beet. For the concentration

⁴ After the sugar has been extracted from the beet, a white fluffy mass representing the "apparent" waste remains. This is termed the *Schnitzel*. It is employed as a fertilizer and as food for stock, thus forming a sort of by-product of considerable value.

of the sugar here it is necessary that the beet taper rather symmetrically, yet tend toward a slight spiral form. It should also end in a very long tap-root (Fig. 2). The form of the beet in relation to the concentration of sugar constitutes a response to rainfall, to be discussed later.

(a) *Planting.* The seed is usually planted in April, that is, as soon as the ground is free from frost. Though it is sown to depths of only two and three centimeters, the soil must be deep. Just as soon as the plant appears above ground the work of cultivation begins. All of this work is accomplished by hand. Even



By permission of Dr. L. Kuntze, Director, Delitzsch Zucker-Fabrik.

FIG. 2—Delitzsch "Elite." Type of beet of highest quality developed in Delitzsch, Germany.

though the fields be not extensive, considerable labor is necessary, since the hand process is extremely slow. There is practically no time between the day of planting and that of harvesting when the sugar beet needs no attention. This gives rise to two important considerations, (a) the loss to the farmer in the event of crop failure and (b) the labor supply. The question of crop failure will be discussed in detail in the second section of this paper, where climatic relations are given special consideration.

A comparison of the map (Fig. 3a) showing the percentage of land devoted to sugar beet growing and that (Fig. 3b) showing the distribution of population or population density brings out a significant relationship. Where the population is dense, there is grown the sugar beet. It cannot be grown economically success-

fully in a thinly populated district. The reasons therefor can be best discussed under two headings—harvesting and sugar extraction.

(b) *Harvesting.* The harvesting of the beet generally commences in October and continues for from four to six weeks. It must be completed within this period—that is, before heavy frosts set in. The plants are uprooted in most instances by a machine—work that is accomplished fairly rapidly. Next, from each plant the crown of foliage must be cut. As yet no machine is employed. Hence each beet must be handled, an exceedingly slow process. Further, those beets which are not taken to the *Fabrik* immediately must be piled in small heaps, but not covered.

The people who perform this labor are primarily women, girls and children—family labor. “A girl who is a very hard worker can harvest three-tenths of an acre in one day. She is paid at the rate of 9 marks (\$2.14) per six-tenths of an acre” (7). This rate assumes that the beets are piled in small heaps, whereas the statement as to the girl’s capacity does not include this process in her day’s work. As a matter of fact, her earning capacity ranges from 2 to 3 marks per day—i.e., 50 to 75 cents. The day generally begins at daybreak and terminates with the last rays of twilight. In the latitude of north Germany the number of hours between these extremes during the growing season is notably large. Such a low wage results in making work by individuals hardly profitable. By a number of members of a single family “clubbing together” the income for the family unit may be substantially enlarged. In addition to the resident labor a large importation is made, consisting of a more or less undesirable class of people from parts of eastern Germany and western Russia. These inroads in themselves give rise to difficult social problems.

(c) *Sugar Extraction.* A map showing the distribution of the *Fabriken* would coincide essentially with that giving the distribution of beets. The *Fabriken* are located as centrally as possible among the fields. Competition of the finished product with cane sugar demands this. Beet sugar must be sold at least as cheaply as cane sugar. The working margin is so close that if the beets must be hauled long distances by rail the freight charges resulting therefrom practically prohibit the extraction of the sugar. Hence most of the beets must be received from the fields without cost to the *Fabrik*⁵. This is accomplished by central location and delivery

⁵ It might be noted incidentally that the *Fabriken* supply the seed free of charge in spring and therefore can demand this delivery under these conditions in the fall.

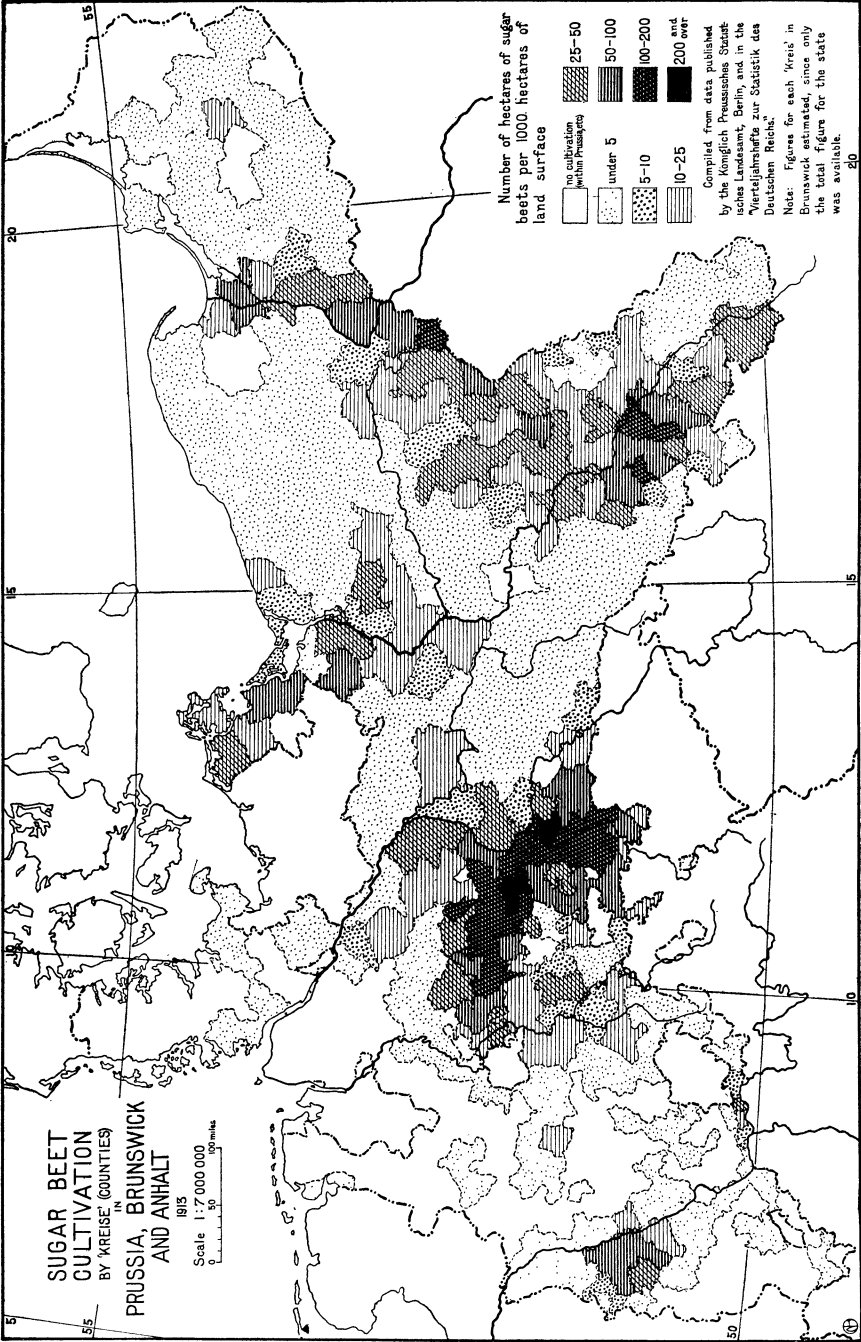


FIG. 34.

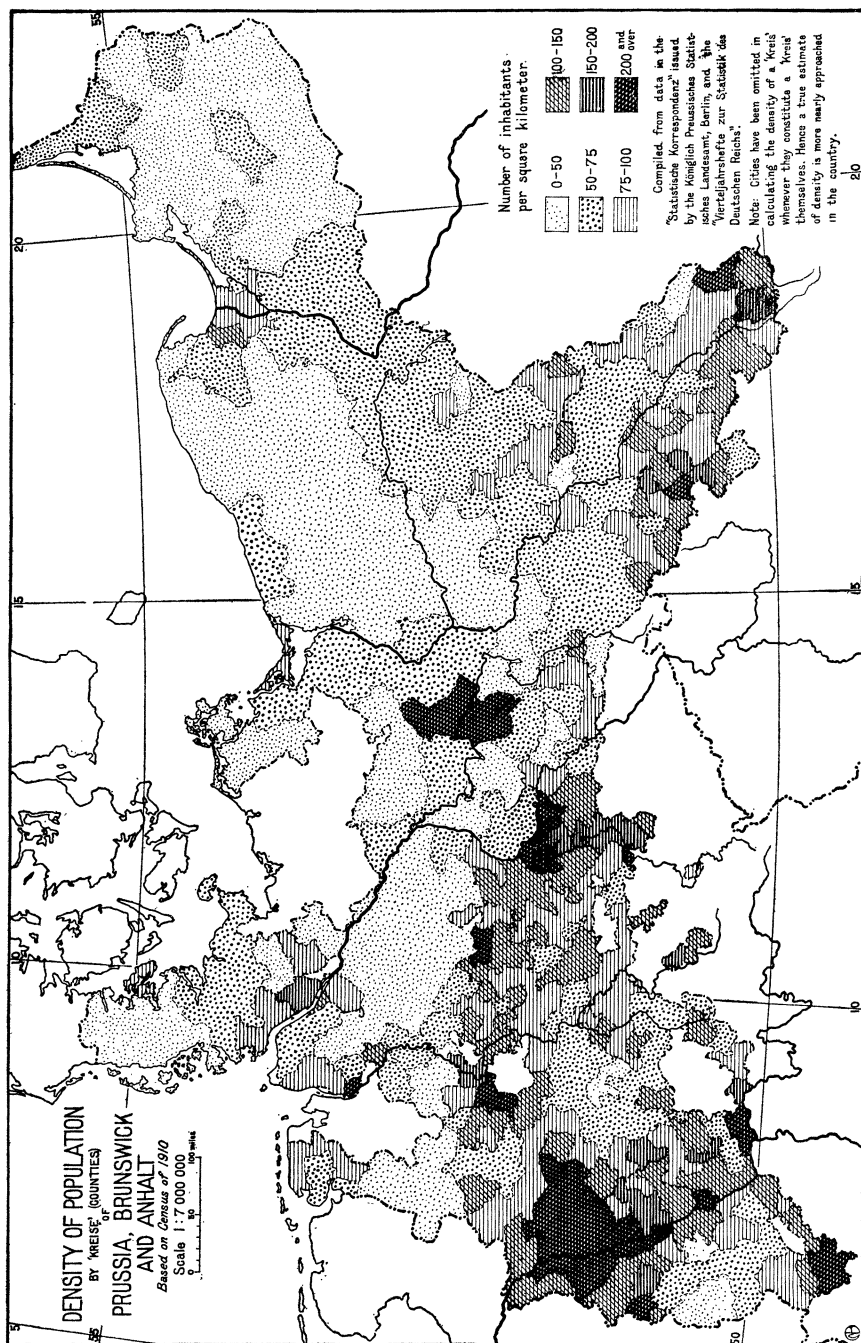


Fig. 3a.

in wagons by the farmers. Thus two very striking relationships present themselves here: (a) the relation between the distribution of population and dependent intensive agriculture and (b) the relation of location of a raw product to the development of its dependent industry.

Soil. The soil in which beets grow is classified as light or heavy. The light soils generally contain a maximum of sand with a mixture of clay or loam, or both; the heavy soils are principally clay or heavy loam with a mixture of sand. (Experimentally, the beet grows best in a lime soil (6).) "A loess soil with a smooth surface slightly inclined to the south, as little stony as possible, rich in



FIG. 4—A sugar beet field during harvest. Delitzsch.

humus, very deep, and a water-filled, non-pebbly subsoil, present the best conditions" (6). It is certain that the soil must be deep and underlain with a subsoil that drains well. The water table must always lie below the surface a distance equal to the greatest depth to which the tap-root will grow.

The heavy and light soils cover large parts of the north German glaciated plain. Although for years the sugar beet fields have occupied in most instances the soils of glaciated lands, recent developments point to the fact that such soils are not absolutely essential.

The productivity of the soil is maintained by the application of artificial fertilizers, by the use of barn manure and by crop rota-

tion. A few of the effective rotations are worth noting. While differing for different localities, their similarity is striking and interesting.

Where sufficient barley can be grown the rotation is as given in column 1 of the table below (1). "In the northwestern part of the Province of Posen, where sandy soil and fine clayey soils predominate," the rotation in column 2 is successful. (6) In Upper Silesia, where there are "heavy cold soils," the rotation indicated in column 3 seems best. "In general the rotation should occur in a three-year cycle. If, however, a four- or five-year rotation can be effected, so much the better" (7).

TABLE I—CROP ROTATION IN SUGAR BEET CULTIVATION

1	2	3
sugar beets	sugar beets or potatoes	sugar beets
potatoes	barley or oats	barley
oats	rye	rye
barley	sugar beets or potatoes	red clover
rye (winter varieties)	potatoes	sugar beets
wheat (" ")	barley or oats	barley or oats
sugar beets	clover	cereals in variety
	sugar beets	wheat
		sugar beets

Climate. The growing season covers six months, April to September inclusive (8). The first period may be divided into three parts, as follows: (a) April–May, with an average temperature of 10.7° C; (b) June–July, with an average temperature of 18.8° C; and (c) August–September, with an average temperature of 16.5° C. The average temperature for the whole period would thus be 15.3° C. (1). The rainfall for the first period should be about 97 mm, for the second period 114 mm and for the third period 100 mm. This is a rather uniform distribution, with, however, a significant maximum during the second period. All growers are not agreed upon these exact figures, though in general they are in accord upon the *relative* amounts. The rainfall of the first period should occur preferably during the latter half or toward the end of the period; that of the second period, always associated with warm weather, should be fairly evenly distributed; while the precipitation in the third period must fall during the first quarter or half, if it is not

to prove destructive. During the third period, especially in September and extending to the end of the harvest in October, much sunshine is essential.



FIG. 5—Driving in to be weighed. Seed warehouse in background. Delitzsch.

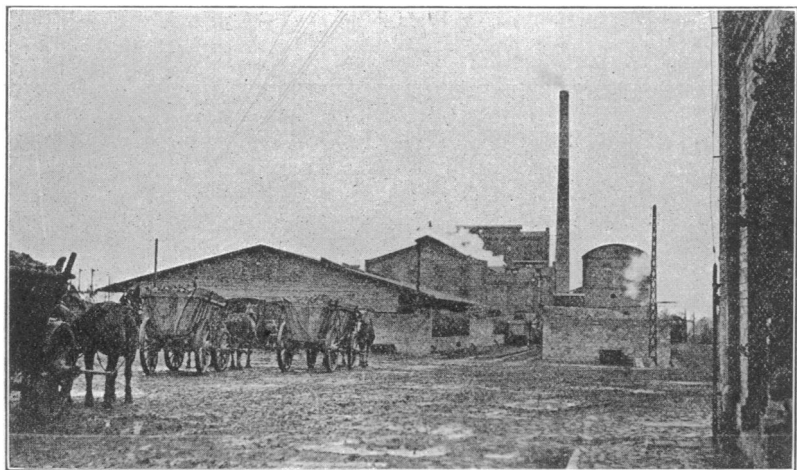


FIG. 6—General view of one of the largest sugar *Fabriken* in Germany. Delitzsch.

As to the effectiveness of sunshine, growers agree pretty well. Sunshine without doubt is the biggest factor in the actual formation of sugar in the plant. However, a difference of opinion exists

as to the relative efficiency of direct insolation and diffuse light. According to Dr. Kuntze⁶, "It is a well-established fact that the growth of sugar in the plant in so-called diffuse light proceeds more intensively and quickly than under the influence of direct sunlight."

Infrequent light frosts in autumn do not affect the beets; however, to frequent light frosts and to heavy frosts they are most sensitive. In consequence of this sensitiveness that part of the crop which is not removed to the *Fabrik* immediately after the harvest is stored in a *Müte*. A *Müte* is a mound of dirt two to three feet high and usually not over fifty feet in length, the

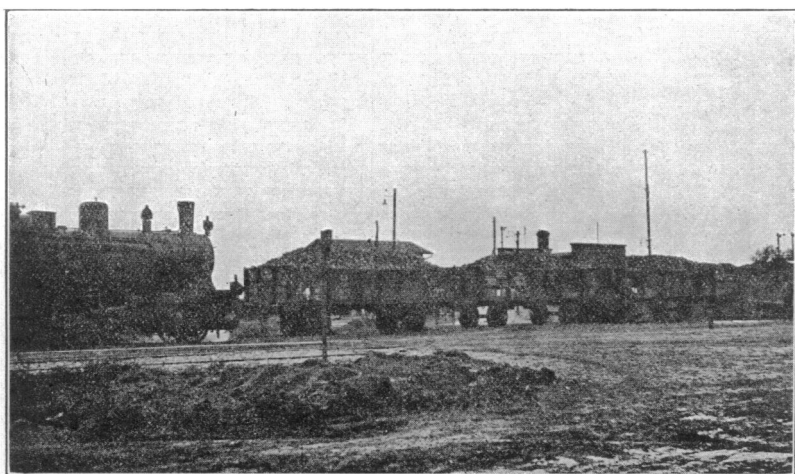


FIG. 7.—The more expensive form of delivery. Nearly all of these loads, however, represent a short haul. Delitzsch.

length varying according to the number of beets to be stored⁷. Its success is dependent upon the structure of the mound in relation to existent weather conditions. When frosts are light the covering of dirt must not be too thick, since the beets may become sufficiently warm to begin growing. On the other hand, when heavy frosts seem imminent then a layer, or several layers, of straw covered by more dirt must be added. Again, in this instance, the farmer must avoid making the bed too warm. Often it is advisable to remove this covering in part when the air temperature rises during the day

⁶Dr. Kuntze is director of the sugar *Fabrik* in Delitzsch and one of the foremost men in Germany as an authority on the subject of beet growing.

⁷Four of these mounds are built on one *Morgen* (.631 acre). This form of storage saves the expense of transfer to a warehouse and later from the warehouse to the *Fabrik*.

and to replace it at night. The fluctuations in temperature must be observed carefully to attain the best results.

In some instances these mounds are oriented with reference to the coldest winds. Thus in the region about Delitzsch the direction is nearly always NE-SW or E-W in response to the cold continental NE or E winds.

Aside from insect pests and diseases that occasionally materially affect the crop, failures or successes are usually accounted for on

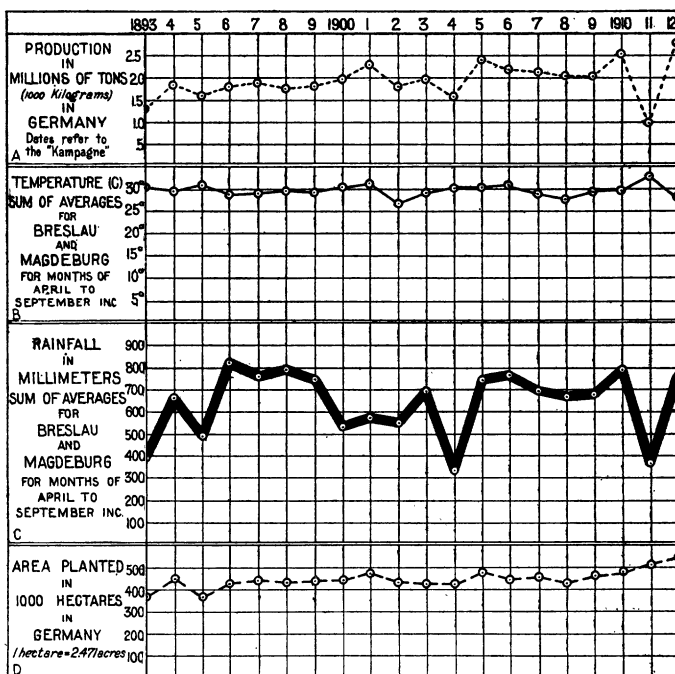


FIG. 8—The apparent dependence of production (for a series of years) upon rainfall and temperature. Ref.—Rathke's *Adressbuch* and *Prussian Yearbook*.

the basis of a wet or dry year. Where the soil is light a relatively wet year is favorable, whereas in areas of heavy soils relatively dry years are desirable. These terms wet and dry refer particularly to the rainfall during the second period. If the rainfall on a heavy soil is abnormally high and the air warm, the beets will grow very rapidly, but the sugar content will be small. If these unusual rains occur in September and October that sugar which is stored in the upper part of the root will be dissipated and accord-

ingly a crop failure result. The failure will be especially considerable if the beets have assumed abnormal shapes, usually very wide at the top and short in length. Inasmuch as the sugar concentrates near the top it may be washed out by the rain waters more easily than in the normal form. At no time is a combination of heavy rainfall and low temperature encouraging.

“Upon light soils during wet years we not only have a large harvest of beets but the sugar content is large, since the beets on

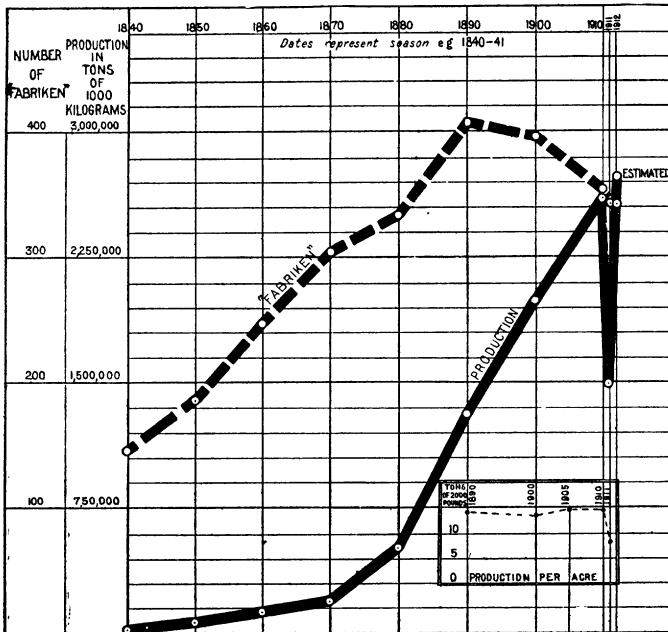


FIG. 9—Relation of number of *Fabriken* to production, showing recent decrease in *Fabriken* with constant increase in production (except for 1911). Note decrease per acre also. Ref.—Rathke's *Adressbuch*.

the average polarize higher; further, they can be worked much more easily since the sugar crystallizes out of the sugar syrup quite readily. During dry years upon light soils, again, the beet possesses a high sugar content, but the sugar does not begin to crystallize out so readily as in wet years” (7).

Production. That the production of sugar beets has always tended to increase is illustrated by the upper and lower parts of Figure 8. The total area (9) planted in 1893 (Fig. 8D) was 386,481 hectares (1 hectare=2.471 acres) and in 1912 it reached

547,850 hectares. The production (9) of sugar during the *Kampagne*⁸ 1893-4 (Fig. 8A) amounted to 1,366,001 tons (tons of 1000 kg) and in 1910-11 nearly doubled this amount, namely, 2,589,900 tons. The small crop of 1911 caused the production of sugar for the *Kampagne* 1911-12 to fall to 1,497,700 tons⁹, abnormally low.

Although the number of *Fabriken* has decreased within the past 12 years (Fig. 9), the production of sugar has in general increased very rapidly. This is due not so much to geographic factors as to the skill and ingenuity of the chemists and engineers, who have steadily improved processes. The consolidation of a number of the smaller *Fabriken* with the larger ones has also been a factor. The detailed curve in Figure 8A gives some idea as to the deviations from the general tendency toward increase in production. Though the causes of the years of decrease will be discussed in detail later,

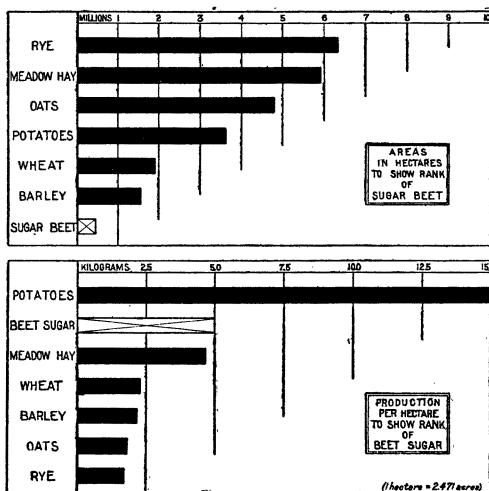


FIG. 10—The rank of the sugar beet versus the rank of beet sugar. Based on data from *Vierteljahrshäfte zur Statistik des Deutschen Reichs*, 1912.

sugar extracted, when ranked with the production of the same items, takes second place. Upon making inquiry into the value of the sugar beet compared with that of the products with which it is rotated and incidentally here ranked, the following statement was received: "With a normal crop, the sugar beet is the most

it will not be amiss to state here incidentally that the decrease in rainfall for the two principal beet-growing districts, Breslau and Magdeburg, was coincident, and further that in 1904 and 1911, years of largest fluctuation, the temperature rose considerably, in the latter year unusually so.

(a) *Rank in Production.* Although in area planted sugar beets rank seventh (Fig. 10) among the leading crops, the quantity of

⁸ *Kampagne* is the winter season during which the sugar is extracted from the beets just harvested.

⁹ The production per acre, shown in the inset on Figure 9, has tended to decrease.

profitable, since in addition to providing sugar both the beet *Kraut* (leafy crown) and the *Schnitzel* constitute valuable food for the stock." Further, "If one takes an average for a series of years, the profits always remain greater than those for grains" (10).

Germany is the leading beet sugar country (Fig. 11). Its present production approximates very closely one-third of the world's total. Russia does not fall far behind. Whether

or not Germany needs to fear Russian competition is a question too complicated to discuss here.

(b) *Beet Sugar and Cane Sugar.* Figure 12 illustrates an interesting contest for supremacy in the output of sugar. Until 1905 beet sugar always led cane sugar. Subsequently the output

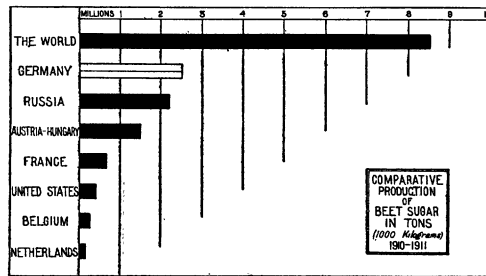


FIG. 11—Germany's rank among the beet producing countries. Ref.—Rathke's Adressbuch.

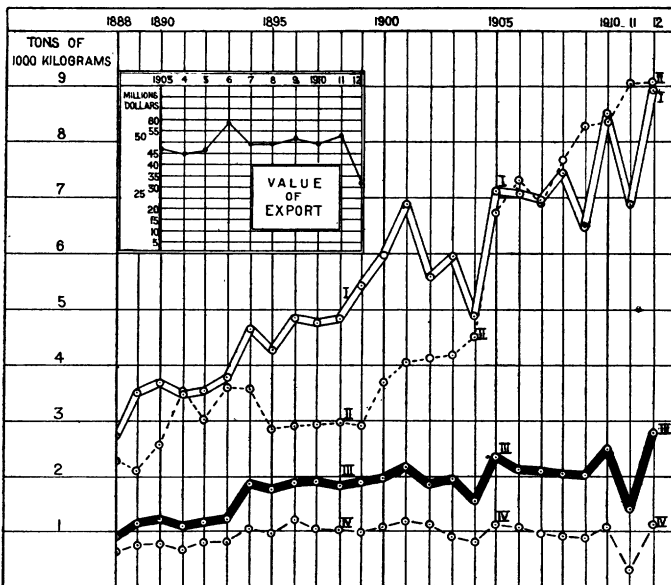


FIG. 12— I—Beet sugar production of the world
 II—Cane " " " "
 III—Beet " " " "
 IV—Beet " " " "
 Inset—Value of German export for series of 10 years.

of both has been very nearly equal, cane sugar having a slight advantage. Still, beet sugar has been none the less important upon the world's markets. The influence of Germany upon the world's output is illustrated in part at least by curves I and III in Figure 12. The fluctuations in both are essentially parallel, the years 1890, 1894, 1895, 1901 to 1905, 1911, and 1912 being especially note-



FIG. 13.—Consumption of sugar in kilograms per capita among the nations, 1911-12.
Ref.—*Rathke's Adressbuch*.

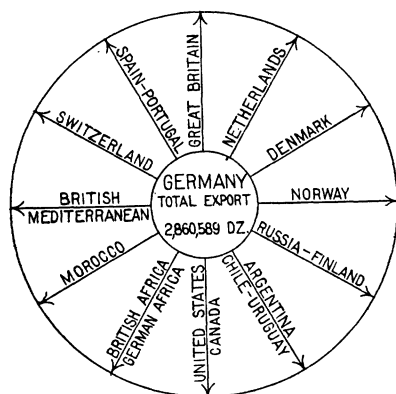


FIG. 14.—Destination of Germany's beet sugar export. 1 *Doppel-Zentner* (dz.)=100 kilograms =220.4 pounds. In 1911-12 the largest export was made to Great Britain, Switzerland, Norway and Uruguay.

worthy. On the other hand, variations in the output of cane sugar are not noticeably reflected in the curve for the world's output.

Commerce: (a) Consumption. The per capita consumption of sugar in Germany is fifth in rank among the nations, as shown by Fig. 13. This rank is the more significant since the four countries which have a larger consumption produce very little beet sugar. The United States is the only one of these which produces a considerable quantity of sugar, and that primarily cane sugar. The consumption per capita in Germany has increased from 7.19 kgs. in 1888 to 18.8 kgs. in 1911. The figure for 1911 represents about one-half the total production. Since the countries which lead Germany in consumption produce so little sugar, there should be a ready market for Germany's surplus.

(b) Export. The export to individual countries from year to year fluctuates very widely. Hence it is impossible to present a graph of the average export to these countries. Figure 14 indicates the countries involved¹⁰. The wide distribution of the export both among European countries and among American countries

¹⁰ The value of the export for a series of years appears in the inset in Figure 12.

deserves notice. The demand from so many different sources coupled with Germany's ability to supply it opens an avenue for trade not alone in this product but naturally in others—hence another reason for the keen interest which Germany should show toward the sugar beet and beet sugar.

Significance to Germany. Upwards of 100,000 people (11) are employed in the German beet sugar industry. Should the export decrease suddenly after a year of normal crop, the following year would witness a decided decrease in area planted, in harvest and accordingly in the number of people employed. This is a possibility, since, as above indicated, cane sugar occupies a place on the market and must be reckoned with. As the annual production of cane sugar continues to increase rapidly, beet sugar seems destined to take second place¹¹. The reasons are fairly obvious. The varieties of sugar are chemically the same; however, the personal experience not alone of the writer but of many others, including some who are intimately associated with the industry, gives evidence that cane sugar has a very much greater sweetening capacity—a fact tending in itself to swing favor in its direction. If the prices of these two sugars are the same, as proves to be true, then certainly the consumer will choose the sweeter variety. Unless the choice is controlled artificially, the consumption of beet sugar must decline and therefore crop production must likewise decrease.

Reference to Figure 12 again brings to light the fact that since 1899, excepting only 1907, the output of cane sugar has never fallen off. The story for beet sugar is quite in contrast. But reliability is a crowning virtue. If the merchant realizes that each year the available quantity of cane sugar is certain, whereas that of beet sugar is uncertain, then there remains no question as to which of the two he will handle. The question "Why is there a difference in degree of certainty?" follows quite naturally. The answer is a rather serious one for Germany.

That both of these varieties are influenced by their climatic environment can hardly be gainsaid. It is true that the sugar beet possesses a rather remarkable adaptability to various climates and soils; nevertheless, the map of distribution and some facts to be discussed below present rather convincing evidence that climate still controls. This is Germany's largest handicap in its problem of beet cultivation.

¹¹ Review of export for 1912-13 (16), which was unusually small. The decrease may be accounted for on the "basis of an unexpected and unprecedented crop in Cuba and the advantage in duties which Cuba has over other sugar-growing regions."

Cane sugar grows where the elements of climate are fairly certain; it grows where labor is even cheaper than in Germany; its cultivation probably demands less attention, and, finally, the harvesting is simpler and easier. In Germany the area possible for the spread of the sugar beet is limited. So far as concerns the present it is about as extensive as possible; the moorlands offer a future provided only that cane sugar does not continue to increase as in the past. The tropics are only beginning to be penetrated; sugar cane is just commencing to be cultivated systematically. That the output of the latter is destined to surpass and possibly even suppress that of the sugar beet, and therefore beet sugar, is hardly to be doubted.

If the beet sugar industry is to be preserved in Germany, in all probability only a high tariff on imported cane sugar can act as a safeguard. There still remain possibilities in the improvement of the variety of the beet and in processes of sugar extraction and refining, but these can accomplish hardly more than the maintenance of the present relation to cane sugar for a little while longer.

Aside from a whole series of artificial factors, principally political, the sugar beet at the present time suffers most of all from climatic influences. Though these cannot be overcome entirely, they can probably be met and solved in part. This is Germany's most important work at home for the improvement and continuance of the industry. The close relation existing between the growth of the sugar beet and the variations in the climatic elements is discussed in the following section.

(To be concluded)